the majority of the nuclei evidenced signs of degeneration. They presented vacuoles of various sizes, some of which were so large as to press the nucleoli far to one side. The surface of the epithelium was represented by numerous layers of flattened cells, with shrivelled and fragmented nuclei, such as are seen in the horny strata of the epithelium of the skin. There was not any infiltration of the subconjunctival or corneal tissue with epithelial cells. Processes of connective tissue, however, extended upward into the epithelium, and carried bloodvessels. The cornea was represented at one end of the sections, and showed destruction of Bowman's membrane with decided round-cell infiltration. The subconjunctival tissue was quite vascular and was moderately infiltrated with round cells.

REMARKS. The clinical symptoms of the case were typically those that are found in circumcorneal hypertrophy of the conjunctiva, as seen in elderly subjects. There were not any gross secondary disturbances such as tessellated granulations in the conjunctiva, neither were there any of the mucoid or mucopurulent secretions that are so frequently noticed in cases of the acute localized types of the affection. The bulk of the mass was composed of the characteristic milky-white nodular depositions. Microscopically, the examination of the hyperplastic tissue about the limbus of the cornea showed a marked increase of the epithelial structures with pronounced sclerosis of the surface cells.

NITROUS OXIDE AND OXYGEN AS A SURGICAL ANÆSTHETIC.

WITH A DESCRIPTION OF A NEW APPARATUS FOR ADMINISTERING THESE GASES AND REPORT OF 100 OPERATIONS, THE NARCOSIS LASTING A HALF HOUR AND UPWARD.[1]

By S. Ormond Goldan, M.D.,
of New York.

In the use of nitrous oxide in combination with pure oxygen we possess an anæsthetic which must have for every operator a double interest —first, its universal safety; second, the fact that there is absolutely no physical condition of the patient which contraindicates its use. All will admit that in the interest of the patient the safest anæsthetic should always be selected. This is rarely done at the present time, for the reason that ether and chloroform are in the vast majority of instances considered the only anæsthetics adapted for surgical purposes. In the rare instances where nitrous oxide and oxygen are selected as the anæsthetic it is as a matter of necessity, not choice; that is, because other anæsthetics, for various reasons, are contraindicated. It might be as well to state right here that where profound and long narcosis is neces-

[1] Read before the College of Physicians of Philadelphia, April 3, 1901.

sary another anæsthetic should be selected; yet as our knowledge increases in the use of this drug its field for usefulness will greatly extend.

The use of a new anæsthetic or method is usually desired by those who have rarely or never used either. Nitrous oxide is so universally associated with dental work that the surgeon is prone to imagine it is not applicable to operations of longer duration; even if he thinks otherwise the old cry of complicated apparatus and great skill, both necessary and hardly obtainable in most hospitals, preclude its use. It is well known that in ordinary gas administration the production of anæsthesia is accompanied with intense cyanosis bordering on asphyxia; efforts have been made to eliminate these asphyxial symptoms by admitting air in various quantities, but in doing so anæsthesia also passed off, the patient becoming conscious.

The inhalation of nitrous oxide alone has very frequently been said to produce its effects simply by asphyxiation, but while true to a certain extent there is no doubt it has pure anæsthetic properties, and nothing demonstrates this more perfectly than its use in combination with pure oxygen gas. Here asphyxial phenomena are entirely avoided, yet if the gases are accurately proportioned perfect surgical anæsthesia can be obtained in most cases.

It is perfectly possible to administer gas alone for long operations. I have so used it; but a little thought will convince anyone that this is not an advisable thing to do, especially where we have gas and oxygen, for to anæsthetize a patient more or less cyanosis is necessary; then a breath or two of fresh air is given and the mask reapplied—that is, before consciousness is regained. This continual deprivation of oxygen, it is well known, abolishes metabolism. It may be questioned whether to keep this up for a long time would not be a more serious method than the use of ether or chloroform. Now the oxygen in the air exists to only about 20 per cent.; 80 per cent. is practically an inert gas (nitrogen), and to use this combined with nitrous oxide means, in the first place, we can never increase the gas sufficiently to obtain anæsthesia and at the same time utilize the oxygen to prevent cyanosis. The oxygen can never be regulated; this method must of necessity be one of deep anæsthesia by gas bordering on asphyxiation. In the administration of an inert gas and a small percentage of oxygen—that is, with the patient alternately anæsthetized and conscious, or nearly so—unless the administrator is particularly skilful it cannot be conducted without great discomfort to the surgeon. In short cases the method has no disadvantages; the surprise is that the dentist alone, and not the surgeon, makes use of it.

It must occur to everyone who administers gas that if a method could be devised by which the oxygen percentage could be regulated by using it pure in combination with nitrous oxide we would have an ideal anæsthetic. Without going into the history of the subject, it is simply necessary to remember that if the inert oxygen can be eliminated the nitrous oxide percentage can be increased just that much; then by using pure oxygen to the amount of 10 per cent. we can obtain perfect anæsthesia with no asphyxia. Does anything prove more conclusively that nitrous oxide has pure anæsthetic properties? Practically it is found that non-cyanotic anæsthesia is obtained by this combination when the oxygen varies between 8 and 15 per cent.

The late Dr. W. W. Van Arsdale, of New York, to whom I am indebted for many practical hints regarding this anæsthetic, used volumetric quantities of these gases in a large number of cases; this was about ten years ago, when this method of anæsthesia was first attracting considerable attention abroad and here. He said that these gases could not be used except in minor cases, the reason being that he could not vary his percentages of oxygen; but he lost sight of two very important practical points—that the same percentage will not answer in all cases, and, furthermore, it must be varied from time to time in the same case. To administer nitrous oxide and oxygen requires a more complicated apparatus than for ether and chloroform, and an absolute essential is the undivided attention of the administrator.

While it is possible to accurately determine the exact proportion of oxygen used in this method of anæsthesia, it is not practicable, as several cylinders would be necessary, each having a different proportion of the gases; then the cylinders would have to be freshly filled, as decomposition is said to take place (Hillischer) when these gases are kept together any length of time, rendering the mixture irrespirable, due to the higher oxides of nitrogen. This method, it can readily be seen, is impracticable. To obviate these difficulties several apparatuses have been devised to administer the gases from separate cylinders, the mixing in varying proportions taking place at the time of inhalation. All these apparatuses give the percentage of oxygen only approximately. We determine the percentage by the condition of the patient, varying, as said before, in ideal narcosis between 8 and 15 per cent., possibly at times more. One of the great features claimed for the apparatus shown is its simplicity; it represents a complete instrument for the following methods: gas alone, gas and ether, gas and oxygen, ether alone. The apparatus consisting of Fig. 1 was first devised for the administration of nitrous oxide gas alone. I then added the aseptic separable ether chamber for the gas-ether method (see *Journal of the American Medical Association*, December 15, 1900).

The gas stop-cock (Fig. 1) contains two valves. The inspiratory valve is set in an inner cylindrical tube, which works by a handle through a right-angled slit in an external cylinder supporting the expiratory valve superiorly, and inferiorly giving attachment to the gas-bag for gas alone, or the inverted Y-shaped tube for gas and oxygen. The valves themselves are made of thin sheet hard rubber, and are

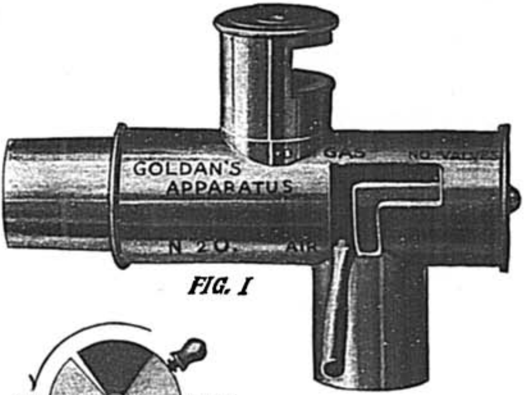


FIG. I

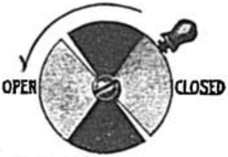


FIG. III

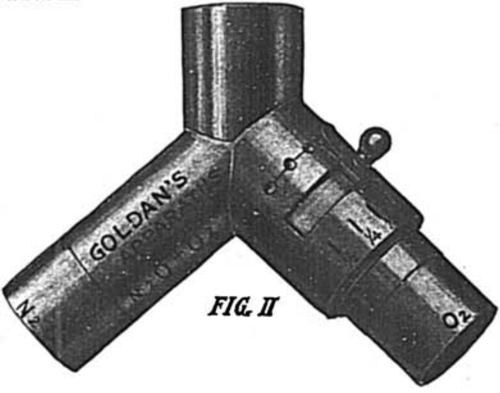
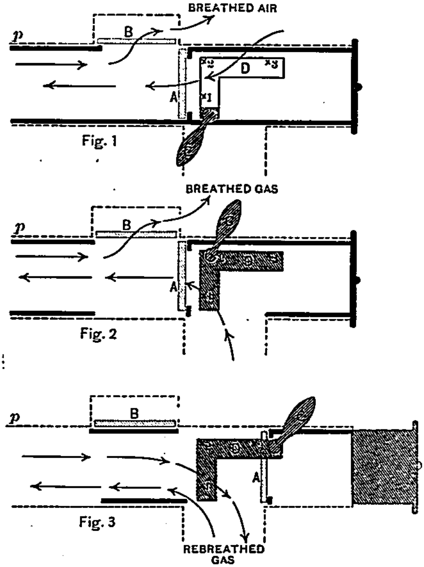


FIG. II

therefore indestructible. When the handle is turned down to the point indicated by " air " (see Fig. 1 diagrammatic plate, Fig. 4) the gas-bag is closed by means of the obturating function of the inner tube; when the handle is turned upward to the place indicated by " gas " air is excluded and gas is inhaled by means of the inspiratory valve. Expirations of the patient pass out through the expiratory valve; at the same time the inspiratory valve is closed.

FIG. 4.



Diagrammatic representation of stop-cock.

Dotted lines indicate external part of stop-cock, heavy lines and shaded part, internal tube. Arrows indicate direction of inspiration and expiration. The valves are indicated by shaded lines. *A*. Inspiratory valve. *B*. Expiratory valve. *C*. Index handle. *D*. Right-angled slit. *P*. Proximal end of stop-cock, attaching face-piece. *X*. Handle turned down; air breathed. *X*2. Handle turned up; gas breathed. *X*3. Handle turned up and back; gas breathed back and forth into gas-bag.

When the handle is pushed backward to the place indicated by " no valves " the valves are thrown out of action; the patient then breathes back and forth into the gas-bag. This three-way action of the stopcock is a feature not represented in any of the dental gas inhalers of American manufacture. This feature is used only with the gas and ether method.

The essential part of the gas and oxygen apparatus is an inverted Y-shaped tube (Fig. 2) attaching to the lower part of the valved stopcock. It will be noticed that the right arm of the tubes is somewhat longer, to accommodate a revolving obturator which regulates the quantity of oxygen. This arm of the tube is so constructed that when the obturator is fully open it represents exactly one-half that of the nitrous oxide arm; if so used it would represent exactly $33^1/_3$ per cent. of oxygen. It may be said that anæsthesia is never possible with such a large percentage of this gas. Graduations are accurately marked on the surface of the tube as $^1/_2$, $^1/_4$, $^1/_8$ $^1/_{16}$, $^1/_{32}$, representing respectively about 33, 25, 12, 6, and 3 per cent. of oxygen; these graduations have always reference to the opposite tube. The surface of the oxygen tube has also small depressions into which the metal spring slips when the oxygen is turned on; this permits the use of the apparatus without taking the attention of the administrator from the patient.

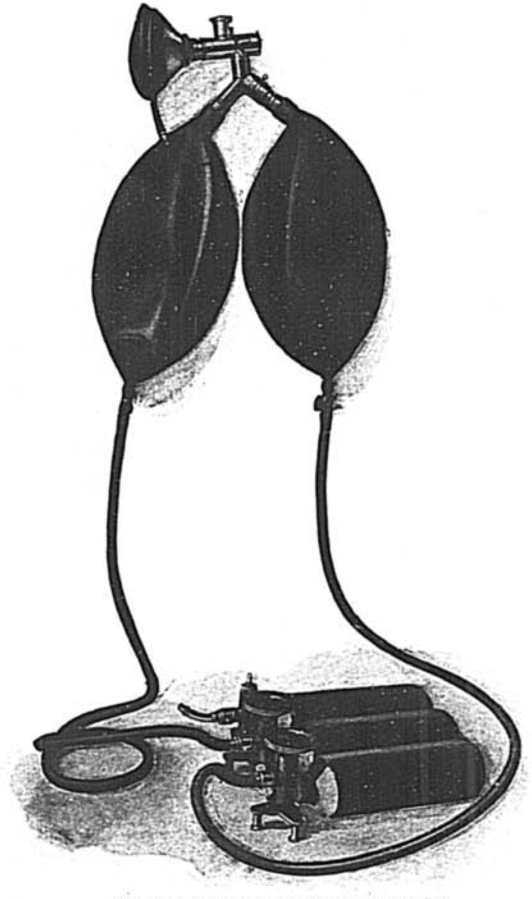
Fig. 3 shows the obturator, which opens by revolving from right to left. The small opening represents about 6 per cent. of oxygen. The vertical arm of the Y is the mixing-chamber for the two gases.

Two separate gas-bags are used, and by this means their respective distention may be more easily seen than with the single bag with septum. From four to six feet of rubber tubing connect the cylinders and gas-bags for transmission of the gases. The cylinders shown are the small portable ones of English manufacture, with foot attachment. Fig. 5 represents the gas and oxygen apparatus complete. There are two cylinders for nitrous oxide and one for oxygen, for the reason that a far greater quantity of nitrous oxide is used than of oxygen. The face-pieces of different sizes may be obtained of rubber, celluloid, or metal, with inflatable rims. For the cases having beards I have had made metal aseptic mouth-pieces of different sizes; these are used when for any reason atmospheric air cannot be entirely excluded when using the mouth-tube the nostrils must of course be closed.

In order to obtain perfect results with nitrous oxide and oxygen particular attention must be given to the following points:

1. The apparatus must be in perfect working order and always tested by the administrator himself.
2. A sufficient supply of both gases at hand.
3. Atmospheric air must be rigidly excluded. In patients with beards the nostrils may be closed; the mouth-tube may be used instead of the face-piece or the beard thoroughly moistened with water.
4. The patient should be prepared as for any surgical anæsthetic.

Fig. 5.



Showing the nitrous oxide and oxygen apparatus complete.

5. The gas-bags should never be fully inflated, but between one-half and two-thirds full. In this way the pressure of the gases is kept more nearly equal.

6. Oxygen should not be turned on immediately the administration begins, but sufficient nitrous oxide inhaled to replace the oxygen existing in the blood; three to six breaths will be sufficient.

Oxygen should be admitted gradually and in quantity determined entirely by the patient's condition, remembering cyanosis calls for more oxygen; evidences of excitement and returning consciousness meaning that less oxygen is required. In using the gases in long narcosis the taps of especially the nitrous oxide cylinders are apt to freeze, owing to the transition of the gas from the liquid to the gaseous state, the cylinders becoming covered with frost; to avoid this a towel wrung out of boiling water should be placed about the tap, but not about the cylinder itself.

The patient should always be placed upon the operating-table in the position in which the operation is to be performed; any position may be employed, providing it will not interfere with the anæsthesia. The preferable postures, in my experience, have been the dorsal and Sims.

Nitrous oxide and oxygen requires about double the time to produce its effect as does the gas alone, the gas alone requiring from 30 to 60 seconds; gas and oxygen from 60 to 120 seconds. In either case consciousness is so quickly lost that I have found it generally impossible to obtain statements from patients as to their subjective symptoms. Sensations are pleasant or unpleasant, depending much upon the temperament of the patient. Hallucinations in some form are not infrequently experienced, and as this may simply take on a pleasant or unpleasant dream it is occasionally difficult to convince the patients that they have not gone through an actual experience. I particularly remember a case where the patient, a man, upon recovering consciousness after gas for a short operation, for some time could not be convinced he had not been to a prize fight. It was an amusing experience to hear his more expressive than elegant remarks regarding the affair.

When inhaling these gases the sensations are much the same as with gas alone; anyone who has inhaled chloroform and nitrous oxide respectively must have noticed the similarity in the peculiar sweetish odor, or rather taste. The oppressive sensations of gas alone are usually absent, providing the gases are not inhaled from a long tube. I find these oppressive symptoms are more often due to the apparatus than to the gas, whether inhaled alone or in combination with oxygen; as the inhalation proceeds there develop paræsthetic sensations in the tips of the toes and fingers and also the tongue. There is a more or less sensory anæsthesia while consciousness is still present. As the jaws become firmly closed it is well to insert a mouth-prop before beginning the administration, and also in oral cases when using the mouth-tube instead of the face-mask. Insensitive conjunctivæ and a snoring respiration are the best signs of anæsthesia in dental cases. This condition of snoring should be permitted for from three to five minutes before removing the mask. It will then be found that the available operative period will be very appreciably longer than it is when using the gas alone. The color at the height of a gas-oxygen narcosis is a pinkish hue, at times slightly bluish, but never the cyanosed condition seen when using the gas alone. The pulse and respiration are approximately normal—somewhat more rapid, if anything, and frequently far better than they were prior to the anæsthesia. The pupils are normal or slightly dilated, never markedly so, and the lids are closed and the conjunctivæ insensitive. Perspiration is profuse, particularly in the longer narcoses. Relaxation in abdominal cases is not as profound as with ether or chloroform, and this, it may be said, is the only serious drawback to the use of this anæsthetic in abdominal work. Consciousness, even in long narcosis, is immediately regained.

It is evident that any agent which is capable of producing insensibility must have more or less shock associated with it. While this is true regarding gas and oxygen, this shock is infinitely less than with ether or chloroform. Convalescence is never delayed with this anæsthetic. Nausea and vomiting occasionally occur, particularly in the longer anæsthesias, but are rarely persistent. Headache, more or less severe, is of not infrequent occurrence. Owing to the large quantities of the gases used, nitrous oxide and oxygen is the most expensive method of anæsthesia. Based upon my own experience, I should say in an operation lasting one hour there would be used from 100 to 150 gallons of nitrous oxide and from 10 to 30 gallons of oxygen.

In the report of the 100 narcoses where nitrous oxide and oxygen was used as the anæsthetic I have selected those lasting a half hour and upward; the shorter cases, covering almost the entire range of minor surgery, as tooth extractions, abscesses, curettings, for a few minutes, etc., I have omitted. In the cases reported the operation in most instances was of shorter duration than the narcosis. When not indicated the narcosis continued from thirty to thirty-five minutes.

1 case	double amputation of the breasts and axillæ . . .	2 hours	40 min.
1 "	single amputation of the breast and axilla . . .	2 "	0 "
1 "	nephrectomy	2 "	25 "
1 "	exploratory cœliotomy for supposed tumor of the stomach	1½ "	0 "
2 cases	appendectomy . . . (respectively) 1½ hours and	1 hour	0 "
2 "	abdominal hysterectomy " 1¼ " "	1 "	0 "
2 "	removal of tubercular lymph nodes (see details of the third case where gas and oxygen were used) . . 1½ and	1¼ hours	
1 case	epicystotomy	1 hour	
1 "	cœliotomy (ovarian cyst)	1 "	
2 cases	perinephritic abscess . . . . each	1 "	

1 case cœliotomy for abscess and removal of deep sutures . . 1 hour.
1 " removal of tumor from thigh and hemorrhoids.
6 cases vaginal hysterectomy, two of these lasting 1 hour each and one 2¼ hours.
1 case prostatic hypertrophy (Bottini).
12 cases dilatation of sphincter and removal of hemorrhoids.
1 case amputation of toes (for gangrene).
3 cases posterior colpotomy.
1 case anterior colpotomy and shortening round ligaments.
2 cases cystoscopy (the position in one of these cases was the complete Trendelenburg).
1 case excising rib.
2 cases removal of axillary glands.
1 case incising and packing mammary abscess.
13 cases uterine curettage (simple).
8 " " " (carcinoma).
5 " " " (puerperal.
1 case exploring, curetting, etc., sinus to kidney.
1 " incising, packing, etc., parotid abscess.
6 cases trachelorrhaphy.
9 " perineorrhaphy.
7 " trachelorrhaphy and perineorrhaphy combined.
2 " varicocele
1 case abdominal wall abscess (typhoid).
1 " catheterizing ureters.

This last case was anæsthetized by me for Dr. Howard Kelly, of Baltimore; the position was a most difficult one for any anæsthetic—that is, the knee-chest for the placing of catheters, then the dorsal for the taking of an X-ray photograph. The patient exhibited some muscular movements of the lower extremities, rendering this photographic feature impossible.

The details of the narcosis I had the pleasure of conducting for Dr. W. W. Keen, in the Jefferson Medical College Hospital, are as follows:

> The patient was a young lady of anæmic type; pulse, respiration, and temperature normal. Anæsthesia was induced with gas and oxygen in two minutes and maintained for thirty-three minutes. Consciousness was completely regained within one minute after the anæsthetic was discontinued. The color of the patient was a healthy pink, occasionally slightly blue. The blood was at times dark, but Dr. Keen said not more so than would occur with ether or chloroform. The pulse and respiration were about normal, pupils moderately dilated, eyelids closed. At the beginning of the operation the patient apparently once felt the knife. The operation consisted of the removal of adherent tubercular lymph nodes, during which the jugular vein was torn and ligated. Altogether the narcosis was a most satisfactory one. I saw the patient about one hour afterward. She had vomited once, the pulse was the same as before the operation, and the general condition good.